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POTENTIAL IMPACTS OF MARINE DEBRIS ON NESTING GREEN SEA TURTLES AT THAMEEHLA ISLAND, MYANMAR*

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Abstract

This study conducted on Thameehla Island, a protected and historically significant sea turtle nesting ground during 2023 to January 2024. The study aims to investigate the impact of increasing marine debris pollution on Green Sea Turtle (Chelonia mydas) nesting behaviors and site selection. The island, located in Ngaputaw Township, Ayeyarwady Region and no human settlement on the island, resulting in less human disturbance to sea turtle nesting compared to surrounding regions. However, the island faces challenges such as beach erosion, and reduced nesting success due to the increasing marine debris issue. The research involved collecting marine debris samples along turtle tracks and on the nesting, area using a quadrat sampling method. Statistical analysis, employing the R software package was conducted. A total of 327 debris pieces across two nesting beaches including all study tracks with and without nests, were gathered. The five most abundant categories were piece of plastic (25%), foam (16%), bottles (15%), net fragments (9%), and rope pieces (8%). Remarkably, marine debris was more abundant in areas with turtle nests compared to those without nests. Statistical tests (p-values of 0.008 and 0.004) indicated a significant correlation between marine debris and nesting success or behavior. The findings strongly support the rejection of the null hypothesis, suggesting that increased marine debris adversely affects Green Sea Turtle nesting. The study concludes that removing marine debris from nesting beaches could potentially enhance nesting habitats, nesting success and contribute to the conservation of sea turtle populations.

Keywords: Marine debris, Green Sea Turtle, nesting behavior, beach erosion, and conservation

Introduction

This study was carried out on the nesting beaches of Thameehla Island, a protected area designated as Thameehla Kyun Wildlife Sanctuary since 1970 during 2023 to January 2024. The island is formerly recognized as Diamond Island due to its diamond shape and currently known as Leik Kyun, reflecting its significance as a nesting site for sea turtle (Leik). The island is situated in Ngaputaw Township in the Ayeyarwady region and holds historical importance as a sea turtle nesting ground. The Green Sea turtle species (*Chelonia mydas*) has been nesting on the island year-round since the British colonial era to the present day. In the past, several thousands of sea turtle came to nest on this island (Maxwell, 1904). Thameehla Island is a major nesting site of green turtles in Myanmar (Maung Maung Lwin & Khin Myo Myo, 2003). Green turtle is the dominant species in Thameehla Island (Ko Myint, 2007 and Maung Maung Lwin, 2009, 2010). However, nesting sea turtle population and number of nests are decreasing with alarming rate year by year likely attributed to factors such as sea turtle bycatch and the degradation of nesting habitats including erosion and pollution (Ko Myint, 2007), (Maung Maung Lwin, 2009), (Limpus, 2012). Presence of large debris on a beach could interrupt nesting activities by turtles causing false crawls. Frequent abortion or disruption on nesting attempts by leatherback turtles was observed in a beach in Gabon in Central Africa where active industrial logging caused accumulation of logs on the beach. Additionally, nest placement may be affected by debris which could affect hatching success (Hays and Speakman, 1993).

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Many sea turtle researchers reported that coastal and marine pollution due to marine debris and plastic pollution can pose negative effects on marine ecosystem and marine species. Marine debris has been identified as one source of habitat degradation and threat to coastal and marine species (Laist, 1997) including sea turtles (Fujisaki, and Lamont, 2016). Marine debris can result from various human activities, such as intense development and increased recreational use of coastal habitats, commercial fisheries, and use of other ocean-based resources by rapidly growing human populations, and natural events such as sea currents and tropical weather systems (Ribic et al., 2010). Marine debris enter into the ocean environment by ocean currents for long distances and then deposited on coastlines or ocean floors (Sheavly and Register, 2007).

Nesting Behaviors of sea turtles

Generally, sea turtles will return to the beach where they were born to nest, natal homing (FAO, 2021). Females lay their eggs high up on the beach usually adjacent to or within vegetated strand. No parental care is exercised. The complete nesting process of the turtle can be divided into eight stages. Stage 1: Emerging from the sea and selecting a course to nest (Note: Sea turtle is very sensitive and may return to the sea without nesting if they are being disturbed). Stage 2: Selecting a nesting site above the high tide level. Stage 3: Clearing the site with sweeping motions of the front and sometimes hind flippers to enclave herself in the body pit. Stage 4: Excavating the egg chamber with her rear flippers to a suitable depth, Stage 5: Laying egg. Stage 6: Filling, covering and packing the nest cavity with sand. Stage 7: Filling of the body pit and concealing of the nest site and Stage 8 Return to the sea (Ali et al., 2004). Generally, the entire nesting process of a sea turtle can range from one to three hours for completion without any disturbances during nesting (https://oceanservice.noaa.gov).

Aim and objectives

The aim of this study is to understand the potential impacts of marine debris on nesting behaviors and nesting site selection along the nesting paths of Green Sea Turtles at Thameehla Island. The specific objectives of the study are to identify and quantify the marine debris, and analyzing with its composition on the study turtle tracks and nest areas and to investigate the behavioral responses of nesting Green Sea turtles especially in selecting of nesting sites, achieving of nesting success in the presence of marine debris along their nesting paths/routes.

Materials and Methods

Study Area

Thamihla Island is a protected area, formerly known Diamon island, currently known as Leik Kyun, situated at coordinates 15^{0} 51′ 46.75″ N and 94^{0} 16′ 43.88″ E in Ngaputaw Township, Ayeyarwady Region (Figure 1). The island was established in 1970 as a Wildlife Sanctuary, positioned near the mouth of the Pathein River. The island has been historically significant as the country's foremost sea turtle nesting site (Maung Maung Lwin & Khin Myo Myo, 2003). The Island has two prominent sea turtle nesting beaches, known as Sattha-Phyu and Then-Ban, which have served as crucial study sites over the years. Sea turtles nest throughout the year on the Thameehla island (Ko Myint, 2007), (Maung Maung Lwin, 2010). Many species inhabit the surrounding waters as their feeding habitat. Historically, two sea turtle species, namely *Chelonia mydas* (Green Sea turtle) and *Lepidochelys olivacea* (Olive Ridley Sea turtle), nested on this island. However, since 2015, Olive Ridley turtle nesting was absent, and currently, only the *Chelonia mydas* (Green Sea turtle) nest on the island year-round. There is no human settlement on the island, resulting in less human disturbance to sea turtle nesting compared to surrounding regions. However, the island faces the problem with increasing marine debris pollution affecting the sea turtle nesting beaches and the environment. This can lead to the beach erosion, decline in the number of nesting sea turtles and hatching success.

Figure 1. Location map of sampling area on both nesting beaches (Statha-Phyu and Than-Ban)

Identification of Marine Debris

Marine debris refers to any persistent, manufactured, or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment. It consists of a wide range of items, including but not limited to plastics, metals, glass, rubber, paper, textiles, discarded-fishing gears, and abandoned vessels. Marine debris can originate from various sources, such as land-based activities, shipping, aquaculture, recreational activities, and natural events (NOAA, 2013), and (Ondara and Dhiauddin, 2020).

In this study, marine debris were categorized as main categories, sub-categories and detail categories based on their characteristics such as plastic, glass, rubber, textiles and wood, utilizing the field guide provided by the NOAA in 2013 and Ondara and Dhiauddin, 2020 contributed to this categorization (Figure 4).

Observation on nesting turtles and selection of turtle tracks

During the survey period, three nesting turtles were observed to indicate their nesting behavior including nest site selection and reaction to the presence of marine debris along their nesting paths during nighttime. Turtle tracks selected randomly with nest or without nest to collect the debris samples on the study beaches. Marine debris survey on the sea turtle tracks with sampling was carried out at morning time to ensure the tracks' freshness and provide a clear view of any marine debris present on the tracks Specifically, tracks left by turtles on the beach the previous night, whether with nests or without nests, were chosen for debris sampling (Figure 3 A,B, C).

Sampling Turtle Tracks

Marine debris survey was carried out at total number of 28 fresh turtle tracks on the two nesting beaches of Thameehla Island. Specifically, on Thanban nesting beach, 6 fresh turtle tracks with nests and 6 fresh turtle tracks without nests were randomly surveyed while on the Sathaphyu nesting beach, 8 fresh turtle tracks with nests and 8 fresh turtle tracks without nests were examined during the survey period. The GPS coordinates of each individual turtle track were recorded at all locations (Table 1).

Table 1. GPS coordinates of sampling turtle tracks on two nesting beaches at Thameehla island.

Track No. (Satthaphyu beach) with nest	Latitude	Longitude	Track No. (Satthaphyu beach) with no nest	Latitude	Longitude
1	15.866378	94.276033	1	15.864825	94.274052
2	15.866266	94.276014	2	15.865109	94.27454
3	15.866008	94.275759	3	15.865239	94.275025
4	15.865838	94.275667	4	15.86547	94.275304
5	15.865645	94.275527	5	15.865799	94.275503
6	15.864918	94.274463	6	15.866114	94.275904
7	15.865339	94.275199	7	15.86657	94.276174
8	15.865183	94.274747	8	15.866356	94.276066
Track No. (Thanban beach) with nest	**Latitude**	**Longitude**	**Track No. (Satthaphyu beach) with nest**	**Latitude**	**Longitude**
1	15.864	94.27961	1	15.865592	94.279736
2	15.86424	94.27957	2	15.865457	94.279747
3	15.86448	94.27951	3	15.864729	94.279553
4	15.86518	94.27958	4	15.864458	94.279581
5	15.860866	94.276796	5	15.864109	94.279578
6	15.86132	94.27687	6	15.86386	94.279518

Sampling Method

Samples of marine debris were collected along the fresh turtle tracks using a quadrat sampling method which was adapted from the quadrat sampling technique employed in the Census of Marine Life investigation (http://www.coml.org). The survey was performed during the early morning to identify unique and fresh characteristics of turtle tracks. Older turtle tracks were excluded from the sampling procedure. A quadrat is constructed measuring 1 meter on each side (1 m²) by using polyvinyl chloride (PVC) pipes (Figure 2B). Five quadrats were randomly positioned along the turtle track to gather marine debris samples. Two quadrats (Q1 &Q2) were placed on the ascending track, one (Q3) on top of the track where turtle nests were located, and the remaining two quadrats (Q 4 & 5) were placed on the descending tracks (Figure 2A, 3C). Any marine debris larger than 2.5 cm in size within the quadrat were collected and recorded, then carefully sorting through each individual quadrat and then it was done by taking a photograph of each quadrat for future analysis.

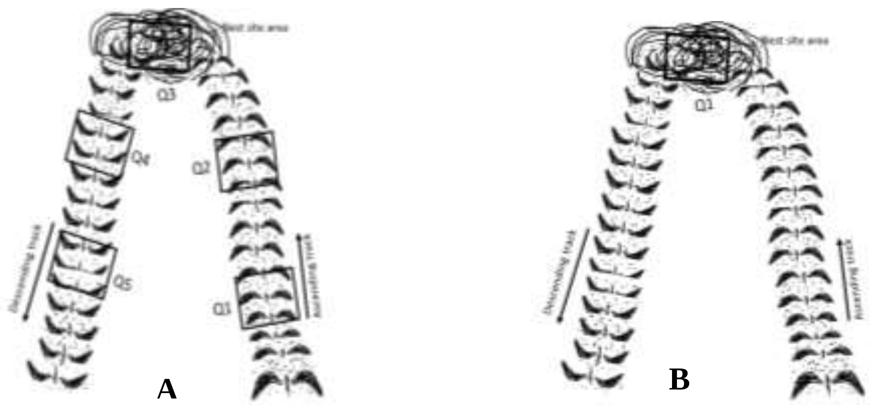


Figure 2. A. Marine debris quadrat sampling along turtle tracks
B. Marine debris quadrat sampling only on the nest area

A B C

Figure 3. A. fresh turtle track with nest
B. Quadrat sample of marine debris on the ascending track
C. Quadrat sample of marine debris on the nest area

Figure 4. Identification of collected marine debris samples

Data Analysis

R, a free statistical software package, was used for data analysis and transformation to find the p-value for the test statistics. It can be compiled and runs on a wide range of UNIX platforms as well as Windows and MacOS. R is available as source code under the terms of the Free Software Foundation's GNU General Public License [The R Project for Statistical Computing]. This paper uses R version 4.1.2 (2021-11-01) - "Bird Hippie" Copyright © 2021 The R Foundation for Statistical Computing Platform: x86_64-w64-mingw32/x64 (64-bit). In this way strong statistical evidence was obtained to provide evidence for the null hypothesis testing. P-values for the t-test were obtained for both marine debris on turtle tracks with nest and without nests, while the marine debris on nest area on the turtle track with nests and without nests during the study period after intelligent calculation of all necessary steps using the R language.

Null Hypothesis (H_o): Nesting success or nesting behavior will not be disrupted by increased levels of plastic debris or pollution at the sea turtle nesting site.

Suppose the alpha level is 0.05 for a tailed test.

To compare marine debris on all study turtle tracks with nest and the track without nest, and marine debris on nest area on the turtle tracks with nests and without nests, paired t-test can be used. With the following factors, two-sample independent t-test was used:

(1) the individual in one sample must be totally unrelated to the individuals in the other sample.,

(2) the sample size is less than 30.

Results

Identification of Marine Debris

Marine debris were mainly categorized based on their characteristics such as plastic, glass, rubber, textiles and wood, utilizing the field guide provided by the NOAA in 2013 and Ondara, and Dhiauddin in 2020 contributed to this categorization. The 14 sub-categories of those group are classified such as Plastic (real plastic, foam plastic, fishing related plastic, juice related plastic, medicinal, beauty, foot wear and other), glass (glass), textile (textile), metal (metal), rubber (tyre), wood (abandoned vessel/boat, construction materials). The 39 detail categories were identified based on their specific characteristics (table 2).

Table. 2. Marine debris identification based on characteristics of collected materials from the study area.

Group	Main Category	Categories
Plastic	Plastic	Bottles, bottle caps, Pic of plastic (Soft)/fragments, Pic of plastic (hard), bags, boxes, sheets/packaging, cups
	Foam plastic	Pic of foam, plates, cups, box
	Fishing related Plastic	Pic of net, pic of rope, floats/ball
	Juice	Straw
	Medicinal	Syringes, tablet package, box/containers, package
	Beauty	Box, containers
	Foot wear	Slipper/shoes
	Other	Smoke Litter, lime box, toys, Packaging (coffee mix, arginimoto), Personal use (e.g., tooth brush, tooth paste container)
Glass		Bottles, cups
Textiles		Cloth, Shoes
Metal	Tin &containers	Tin containers
Rubber/tyre		Sipper, Pic of bicycle or others
Wood	Broken wood or load	Pices related to fishing boats, and construction

Number of marine debris collected from all-study turtle tracks

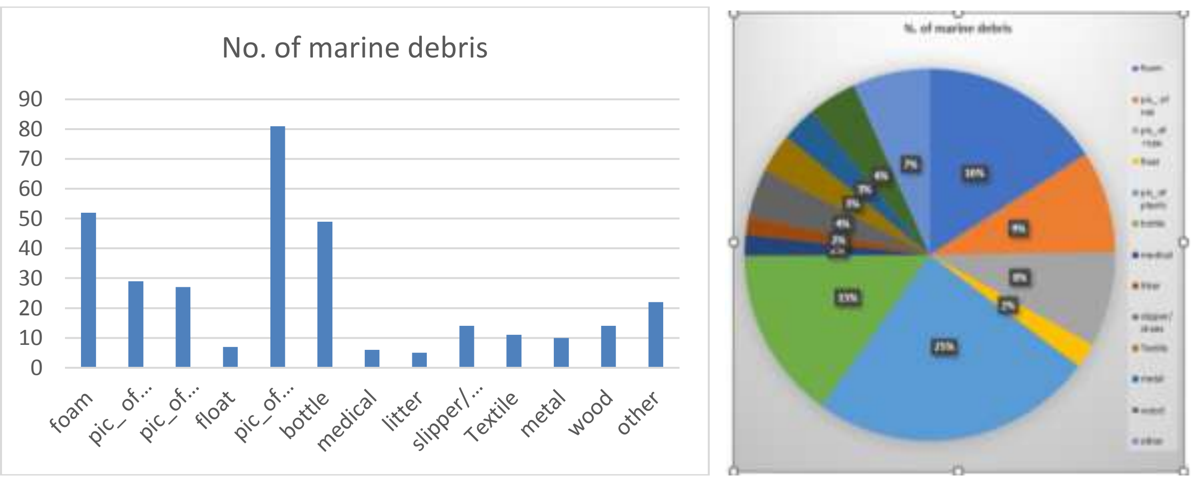
A total of 327 pieces of marine debris were collected from all sampling turtle tracks from two nesting beaches in the study area. Among these, 141 debris items were found along tracks with nests, while the remaining 186 debris items were collected from tracks without nests (Table 3). The findings indicated the presence of marine debris along every turtle track with a nest, average 10.07 pieces (n=14) while the turtle track without nest found an average of approx..13.2857 pieces of debris (n=14). The study found that the quantity of marine debris on turtle tracks without nests are larger than the amount on tracks with nests.

The focus of marine debris collection was on the turtle nest areas along the tracks. A total of 129 debris pieces were collected from the sample turtle tracks within the study area (Table 3). Sampling collection efforts included both the nest areas on tracks with nests and those without nests, assessing for a comparison of debris abundance between the two. Specifically, 48 debris pieces were collected from nest areas on tracks with nests, while 81 pieces were obtained from nest areas on tracks without nests. The findings indicated the presence of marine debris on nest area in every turtle track with a nest, average 3.4286 pieces (n=14) while the turtle track without nest found an average of approx. 5.79 pieces of debris (n=14). The finding showed that the quantity of debris items found in each nest area of turtle tracks without nests is approximately twice as high as that in every nest area of turtle tracks with nests within the study area.

During the study, marine debris collected was classified into 13 main categories, including foam, pieces of net, pieces of rope, floats, pieces of plastic, bottles, medical waste, smoke litters, slippers or shoes, textiles, metal, wood, and others (Figure 5A). Among these, the five most abundant categories were identified, with pieces of plastic, the most abundant at 25%, followed by foam at 16%, bottles at 15%, pieces of net at 9%, and pieces of rope at 8%. While, the medical waste, smoke litters, and floats were among the least categories, each representing 2% of the collected debris (Figure 5B). The study revealed that the main categories of marine debris such as plastic fragments, foam plastic, bottles, fishing nets, and ropes, mainly consist of plastic and materials associated with fishing.

Table 3. Summary of marine debris distribution on sea turtle tracks and nest areas with nests and without nests in the study beaches.

	foam	pic_ of net	pic_of rope	float	pic_of plastic	bottle	medical	litter	slipper/ shoes	Textile	metal	wood	other	Total
Debris on the tracks with nest	23	22	12	0	41	20	0	1	3	4	4	8	3	141
Debris on the tracks without nest	29	7	15	7	40	29	6	4	11	7	6	6	19	186
Total-Debris on all study tracks	52	29	27	7	81	49	6	5	14	11	10	14	22	327
Debris on the nest area with nest	9	8	5	0	11	6	0	1	0	1	2	4	1	48
Debris on the nest area without nest	12	3	6	2	14	12	4	3	6	5	4	3	7	81
Total-Debris on all nest areas	21	11	11	2	25	18	4	4	6	6	6	7	8	129



A **B**

Figure 5. A. No. of marine debris collected from the sampling tracks
B. Composition of marine debris (%) collected from the sampling tracks

Nesting Turtle Behavior

According to literature, sea turtle lay eggs on the sandy beach and avoid any disturbance on the beach. They are highly sensitive to any disruptions or pollution when they arrive at the beach for the nesting process. In this study, it was observed that Green sea turtles excavated their nest holes more frequently and spend a longer duration compared to the normal nesting process (one to three hours). Some turtles experienced difficulties nesting and altered frequently nest sites probably due to the presence of marine debris and vegetation on nest area, then returned to the sea without nesting (Table 3).

Table 3. **Summary of nesting turtle behavior associate with the presence of marine debris on their nesting paths in the study area**

Date of observation	Nesting turtle species	No. of track	Beach and GPS coordinates	Tag number	Time taken for nesting process	Nesting behavior associated with presence of marine debris along the nesting paths/tracks
May 24, 2023	*Chelonia mydas*	Track No.2 with-no nest	Satha phyu 15.865109 N 94.27454 E	MM-2740	45-minutes	-Unsuccessful nesting attempt -Searching for suitable nest sites, but unable to find a suitable location -After attempting to dig nest holes in two different spots among marine debris and vegetation, -Then returned to the sea without successfully nesting -Found bottle, foam and pic of rope in every nest sport
May 25, 2023		Track No. 3 with nest	Satha phyu 15.865645 N 94.275527 E		5-hours	-Successful nesting attempt -Searching for suitable nest sites, -After attempting to dig nest holes in five different spots among marine debris and vegetation, -Successful of nesting -Then returned to the sea -Found bottle, foam, slippers, smoke litters and pic of rope in nest sports
October 16, 2023		Track No.6 with nest	Satha phyu 15.864918 N 94.274463 E	MM 3033/ MM 3034	3:30 hours	-Successful nesting attempt -Searching for suitable nest sites, -After attempting to dig nest holes in two different spots among marine debris and vegetation, -Successful of nesting -Then returned to the sea -Found bottle, caps, float, foam, slippers, and pic of net in nest sports
October 17, 2023		Track No.7 with-no nest	Satha phyu 15.86657 N 94.276174 E	MM 3027/MM 3028	1:30 hours	-Unsuccessful nesting attempt -Searching for suitable nest sites, but unable to find a suitable location -After attempting to dig nest holes in three different spots among marine debris and vegetation, -Then returned to the sea without successfully nesting -Found pic of foam, pic of plastic, cloths, slipper and pic of rope in nest attempting areas

The data analysis revealed that in comparison of marine debris on the turtle tracks with nests and without nests in the study area, the p-value is 0.008, which is less than the alpha level of 0.05 that we have chosen. This means that we can reject the null hypothesis. There is sufficient evidence to reject that nesting success or nesting behavior is not affected by increased levels of plastic debris or pollution at Green turtle nesting process.

For the data analysis in comparison of marine debris on the nest areas on the turtle tracks with nests and without nests, the p-value is 0.004, less than our chosen alpha level of 0.05. On the basis of this result, we can reject the null hypothesis. There is strong evidence to reject the null hypothesis that we have chosen to test, suggesting that there is enough evidence to support the alternative hypothesis *Ha* that nesting success or nesting behavior is affected by increased levels of plastic debris or pollution at Green turtle nesting process. It can be seen that the null hypothesis can be rejected as all p-values for all statistical significance are less than the alpha level of 0.05.

Discussion

The study found that the prevalence of marine debris was higher in areas with turtle nests compared to those without nests. It was suggested that presence of marine debris on both nesting turtle routes and turtle nesting sites can disturb nesting processes and reduce the nesting success. Study on nesting behavior and response of green sea turtles to the presence of marine debris on nesting routes and nesting sites observed that Green sea turtles excavated their nest holes more frequently and spend a longer duration compared to the normal nesting process. Some turtles experienced difficulties nesting and altered frequently nest sites probably due to sensitive to disturbances caused by marine debris when they search for nesting sites at the beach for nesting. Regard on these matters, Laurence et al., 2008 stated that the presence of large debris on a beach could interrupt nesting activities by turtles causing false crawls. Additionally, nest placement may be affected by debris which could affect hatching success (Hays and Speakman, 1993). In addition, (Bourgeois, 2009), (Witherington et al., 2011). reported that the presence of large debris on a sandy beach could alter the spatial distribution of sea turtle nests by influencing turtle nest site selection.

During the study, marine debris collected was classified into 13 main categories, among these, the five most abundant categories were identified, with pieces of plastic, the most abundant, followed by Styrofoam, bottles, pieces of net, and pieces of rope, mainly consist of plastic and materials associated with fishing will have negative impact on nesting beach and nesting process of sea turtles. Nelms et al., (2016) identified the risks that plastics pose towards sea turtles under the headings of ingestion, entanglement, obstacles, impacts on nesting beaches and ecosystem effects. Triessnig et al., 2012 described that marine debris is an indicator of habitat quality for sea turtle nesting sites. The study suggest that removal of marine debris may open nesting habitat that was previously unavailable for sea turtle nesting.

For the data analysis in comparison of marine debris on the nest areas and on the turtle tracks with nests and without nests, the p-values (0.008 and 0.004) are less than our chosen alpha level of 0.05. On the basis of this result, we can reject the null hypothesis as all p-values for all statistical significance are less than the alpha level of 0.05. There is strong evidence to reject the null hypothesis that we have chosen to test, suggesting that there is enough evidence to support the alternative hypothesis *Ha* that nesting success or nesting behavior is affected by increased levels of marine debris at Green turtle nesting process.

Conclusion

There were 13 different kinds of marine debris were recorded on the turtle tracks and nest area. Among these, the most abundant categories were pieces of plastic, the most abundant, followed by Styrofoam, bottles, pieces of net, and pieces of rope. Notably, the prevalence of marine debris was higher in areas with turtle nests compared to those without nests. Statistical analysis indicates a rejection of the null hypothesis, as all p-values for statistical significance were below the predetermined alpha level of 0.05. There is strong evidence to reject the null hypothesis that we have chosen to test, suggesting that there is enough evidence to support the alternative hypothesis *Ha* that nesting success or nesting behavior is affected by increased levels of marine debris at Green turtle nesting process. As a final conclusion, the removal of marine debris on the sea turtle nesting beach may open nesting habitat that was previously unavailable for sea turtle nesting.

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